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FLOOD INSURANCE STUDY

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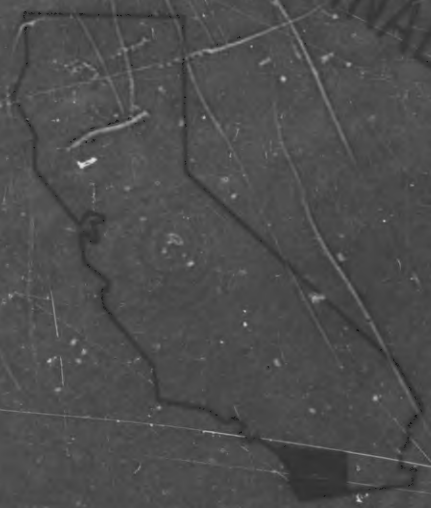

CITY OF
DEL MAR,
CALIFORNIA
SAN DIEGO COUNTY

APRIL 15, 1986

Federal Emergency Management Agency

COMMUNITY NUMBER 060288

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San Dieguito River Panels 01P-03P

Exhibit 2 - Flood Boundary and Floodway Map

PUBLISHED SEPARATELY:

Flood Insurance Rate Map

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1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study has been prepared to revise and update a previous Flood Insurance Study/Flood Insurance Rate Map for the City of Del Mar, California. This information will be used by Del Mar to update existing flood plain regulations as part of the regular program of flood insurance by the Federal Emergency Management Agency (FEMA). The information will also be used by local and regional planners to further promote sound land use and flood plain development.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for the Pacific Ocean were performed by Tetra Tech, Inc., under Contract No. H-4543. A regression analysis was used to supersede the approximate coastal analysis and to update the coastal analysis done by Tetra Tech. This regression analysis was performed by Dames & Moore under Contract No. C-0970.

The hydrologic and hydraulic analyses for Soledad Canyon were performed by the California Department of Water Resources, under Contract No. C-0452. The hydraulic analysis of the San Dieguito River was performed by George S. Nolte and Associates for the FEMA under Contract No. EMW-83-C-1163. This work, which was completed in February 1985, covered all significant flooding sources affecting the City of Del Mar.

1.3 Coordination

The following agencies were contacted to explore all possible sources of data, including information describing hydrological conditions, drainage patterns, historical storm systems, tides and waves as well as information on the topography, roads, bench marks, beach profiles, shelf bathymetry flood protection structures

(seawalls, breakwaters), and the demography of coastal communities in San Diego County:

California American Water Company
California Coastal Commission
California Department of Transportation
CH2M HILL, Inc.
City of Carlsbad, California
City of Chula Vista, California
City of Coronado, California
City of Del Mar, California
City of Imperial Beach, California
City of National City, California
City of Oceanside, California
City of San Diego, California
Comprehensive Planning Organization of the San Diego Region
Federal Emergency Management Agency
Leedshill-Herkenhoff, Inc.
National Oceanic and Atmospheric Administration, Eastern Pacific Hurricane Center
National Oceanic and Atmospheric Administration, National Climatic Center
National Oceanic and Atmospheric Administration, Tide Predictions Branch
National Weather Service, Los Angeles, California
San Diego Coast Regional Commission
San Diego County Department of Sanitation and Flood Control
San Diego Public Library
Scripps Institute of Oceanography
Security Pacific Bank
U.S. Army Corps of Engineers, Coastal Engineering Research Center
U.S. Army Corps of Engineers, Los Angeles District
U.S. Army Corps of Engineers, Waterways Experiment Station
U.S. Department of Defense, Fleet Numerical Weather Center
U.S. Geological Survey

The state coordinator was involved in this study through the FEMA San Francisco Regional Office.

The final community coordination meeting was held on November 8, 1984, and was attended by representatives of FEMA, the study contractor, and the city. No problems were raised at the meeting.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated areas of the City of Del Mar, San Diego, California. The area of study is shown on the Vicinity Map (Figure 1).

The Pacific coastal areas, the Soledad Canyon, and the San Dieguito River were studied in detail within the corporate limits.

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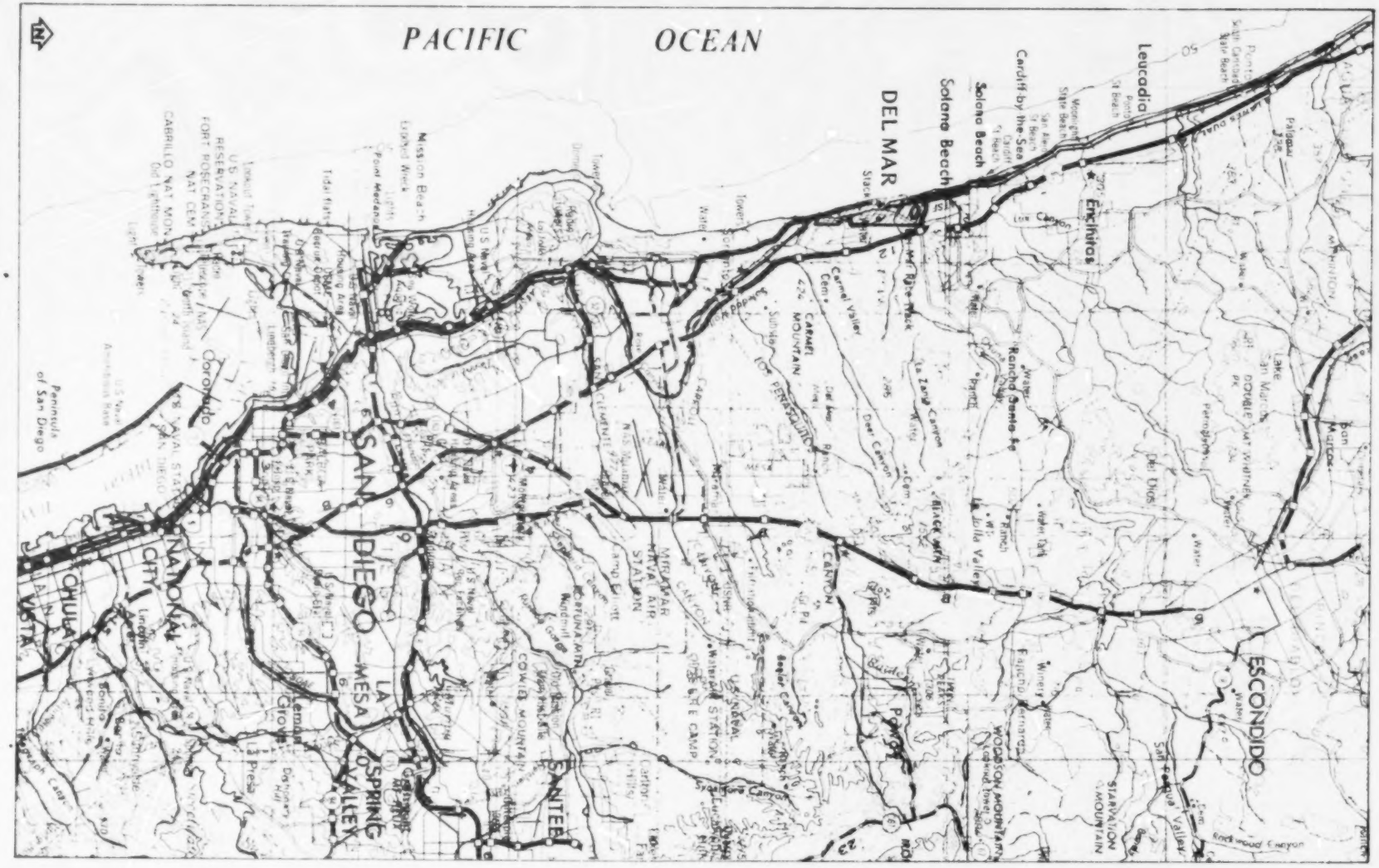
PACIFIC OCEAN
DEL MAR
Solana Beach
Encinitas
Leucadia
Cardiff by the Sea
Carmel Valley
CARMEL MOUNTAIN
Rancho Santa Fe
La Jolla Valley
Del Dios
Lake San Marcos
San Marcos
ESCONDIDO
Escondido
Valley Center
Pauma Valley
Peninsula of San Diego
Coronado
NATIONAL CITY
CHULA VISTA
SAN DIEGO
LA MESA
SPRING VALLEY
LEMON GROVE
La Presa
EL CAJON
Poway
MIRAMAR NAVAL AIR STATION
MARINE CORPS AIR STATION
MIRAMAR
CAMP ELLIOTT
WOODSON MOUNTAIN
STARVATION MOUNTAIN
Black Mtn.
Pomerado
Mt. Woodson
Mt. Ecker
Mt. Palomar
Palomar Observatory
Palomar Mtn.
Lookout Tower
Fallbrook
Winery
Pala
Rincon
Pauma Valley
Escondido Creek
Escondido Canyon
Dictionary Hill
Point Medanos
Mission Beach
Tower
Tidal flats
Beacon
Light
Lighthouse
Ammunition Depot
Ammunition Pier
Submarine Base
Submarine Piers
Submarine Repair Basin
Submarine Training Facility
Submarine Training Tank
Submarine Training Tower
Submarine Training Pier
Submarine Training Basin
Submarine Training Building
Submarine Training Area
Submarine Training Range

The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development or proposed construction through 1990.

2.2 Community Description

The City of Del Mar is located in west-central San Diego County, in southwestern California. Del Mar is bordered by the City of San Diego on the east and south, unincorporated areas of San Diego County on the north, and the Pacific Ocean on the west. Incorporated in 1959, the city had a 1980 population of 5,017, an increase of 26.8 percent from 1970.

Del Mar is a Spanish name meaning "of the sea." The community was first established as a literary and art center in 1885, and was named for a poem by Bayard Taylor called "Fight at the Paseo del Mar."

Del Mar is the home of the Del Mar "Where the Turf Meets the Surf" Race Track and the Del Mar Exposition. It is near the Gulf General Atomic Plant, the University of California, Veterans Hospital, Scripps Clinic and Hospital, Salk Institute, Sorrento Valley-Torrey Pines Industrial Park, and many other major projects.

San Dieguito River flows westerly through the northern half of the city just south of the Del Mar racetrack. The river is controlled 9.5 miles upstream by Lake Hodges Dam. Upstream of the dam, the Santa Ysabel River contributes to the San Dieguito drainage. The Santa Ysabel River is controlled 38 miles upstream of Del Mar by the Sutherland Dam. The San Dieguito watershed is comprised of 347 square miles. The average slope for the approximately 1 mile of river flowing through Del Mar is 3 feet per mile. Soledad Canyon flows westerly just south of the city.

The city is characterized by low-density residential neighborhoods, scenic topography and landforms, wide beaches, and a small village retail center. Del Mar is both a winter and summer resort, noted for its equable climate, with an average winter temperature of 55°F in January and an average summer temperature of 72°F in August.

2.3 Principal Flood Problems

The southern California coastline is exposed to waves generated by winter and summer storms originating in the Pacific Ocean. These storms can cause 15-foot breakers. The occurrence of such storm events in combination with high astronomical tides and strong winds can cause a significant wave runup and allow storm waves to attack higher than normal elevations along the coastline. When this occurs, shoreline erosion and coastal flooding frequently damage inadequately protected structures and facilities located along low-lying portions of the shoreline.

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Another major cause of flooding in the City of Del Mar is long-duration, high-intensity storms in the San Dieguito watershed. Large floods occurred in the San Dieguito drainage area in 1939, 1940, 1977-78, 1980, and 1982.

Brief descriptions of several significant storm events are presented for historical information to which coastal and riverine flood hazards and flood depths can be compared (References 1, 2, 3, 4, and 5).

September 24, 1939

A tropical cyclone, which was due west of San Diego and moved up the coast toward Los Angeles, caused much damage in San Diego County. Winds ranged from 30 to 60 miles per hour (mph) in the coastal communities. Considerable wind damage occurred. Point Loma and Mission Beach were particularly hard hit.

A 20-foot fishing boat went ashore near Cardiff and was battered to pieces. At Oceanside, the fishing pier, normally 27 feet above the waterline, was closed after waves began smashing over the structure. Six pleasure craft were washed ashore at the San Diego Yacht Club harbor at Roseville.

December 26, 1940

Mission Beach, Ocean Beach, and Oceanside were the target of a series of high waves riding a high 7.1-foot spring tide.

The forerunner of the storm was observed off Baja California from the research ship E.W. Scripps prior to December 23. Swells coming from that storm were 50 feet high. More than 3.5 inches of rain fell in San Diego on December 23 and 24. Unusually large breakers began appearing at Oceanside and at Ocean Beach on December 25. On December 26, 20-foot waves smashed over the beach at Ocean Beach imperiling five houses at the foot of Saratoga Avenue. Damage to structures at the foot of Cape May Avenue was also reported. One thousand sandbags were stacked to prevent the surf from undermining foundations of houses. Five hundred tons of rock were placed south of the Mission Beach seawall to break the waves, which sent water surging across Mission Boulevard and into Mission Bay.

At Oceanside, high waves were observed breaking over the end of the pier. Erosion at the Wisconsin Street ramp was observed. Sand bags were used to protect El Sereno Court.

Winter 1977-1978

The entire coastline in San Diego County was hit hard by high-storm waves. Damage occurred to private homes as well as to State, city, and county facilities. Private residences located along coastal

bluffs between La Jolla and Oceanside were threatened or damaged by waves. In Oceanside, 10-foot breakers flooded the first floor of an apartment building causing $500,000 in damage. Stairs, bulkheads, and rock protection belonging to private residents in Carlsbad were destroyed or damaged by waves. As much as four vertical feet of each sand was washed away in some areas. The south jetty in Oceanside lost 30 feet of its end and the entire length was weakened by waves. Total damage was estimated between $280,000 and $375,000. Approximately 300 feet of the seaward end of the Oceanside Municipal Pier was destroyed, amounting to $450,000 of damage. Smaller damage caused by waves occurred at various points along the shoreline.

The winter of 1977-78 showed that severe storms coupled with intensified rainfall and large waves may cause more erosion along the coastline in a shorter period of time than erosion during years of normal weathering.

January-February 1980

The storm periods of January and February 1980 were characterized by successive waves of rain-bearing clouds driven from the central Pacific by jetstream patterns more southerly than usual. Storms were more severe both north and south of San Diego at various times because of the random distribution of rain clouds and greater orographic effects in the higher mountains.

In the 1980 storms, about 15 to 20 inches accumulated over approximately 6 weeks, followed immediately by the storm of February 20-21. At this time, most county reservoirs peaked and local streams reached maximum levels. Evacuation was necessary, particularly in Lakeside and San Diego-Mission Valley. Another severe storm approached on the evening of February 21-22, which could have had disastrous effects. Business halted for evacuation on the afternoon of February 21, until National Weather Service satellite pictures revealed that the storm was breaking up. This storm resulted in a peak outflow of 22,000 cfs at Lake Hodges. The exceedence probability of this peak discharge is 0.025, equivalent to a 40-year event.

This was the most severe storm since those of 1916 and 1927 in most county areas. A comparison of county rain charts shows the January 1916 rain almost double the February 1980 rain and slightly less than the combined totals for January and February 1980. The rain chart for February 1927 is comparable to the February 1980 chart, although the record rainfall of 12.8 inches at Cuyamaca on February 16, 1927, was not approached.

2.4 Flood Protection Measures

There are no known engineering projects installed or planned specifically for protection against coastal flooding in the City of Del Mar. However, in the coastal zone within the county, breakwaters and seawalls exist along the shore, designed to absorb the

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impact of wave forces. These provide protection for small craft in harbors. In some instances, the wall along Strand Way on Mission Beach and the off-shore submerged breakwater under construction at Imperial Beach may also serve as flood protection measures.

In the riverine zone, Lake Hodges on the San Dieguito River and Sutherland Reservoir on the Santa Isabel River provide incidental flood protection, although their main purpose is to provide water storage. Del Mar and other communities within San Diego County are participating in either the Emergency or Regular Phase of the National Flood Insurance Program (NFIP).

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1 percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each flooding source studied in detail affecting the community.

The floodflows for the San Dieguito River were taken from a study by Leedshill-Herkenhoff, Inc., for the City of Del Mar (Reference 6). They routed the hydrographs developed by Boyle Engineering, Inc., for Santa Ysabel Creek through Lake Hodges Reservoir and down the San Dieguito River to Del Mar. Maximum storage conditions in the Lake Hodges Reservoir were assumed.

Peak discharges on Soledad Canyon were taken from discharge-frequency curves developed from frequency curves for similarly gaged streams

throughout the country. To draw the curve, the Standard Project Flood was calculated using the Generalized Standard Project Rainflood Criteria for Southern California Coastal Streams (Reference 7) and routed by the Muskingum method. Discharges taken from the Leedshill-Herkenhoff report (Reference 6) are shown decreasing as the river approaches its mouth due to hydrograph modeling.

Peak discharge-drainage area relationships for Soledad Canyon and the San Dieguito River are shown in Table 1.

The principal source of coastal flooding in San Diego County is from the Pacific Ocean and its landward intrusions such as San Diego Bay, Mission Bay, and the slough near the mouth of Tijuana River.

Coastal flooding is attributed to the following mechanisms:

1. Swell runup from intense offshore winter storms in the Pacific

2. Tsunamis from the Aleutian-Alaskan and Peru-Chile trenches

3. Runup from wind waves generated by landfalling storms

4. Swell runup from waves generated off Baja California by tropical cyclones

5. Effects of landfalling tropical cyclones

The influence of the astronomical tides on coastal flooding is also incorporated in each of the above mechanisms. A flood-producing event from any of the above mechanisms is considered to occur with a random phase of the astronomical tide. Each of the above mechanisms is considered to act alone. That is, the joint occurrence of any combination of the above mechanisms in a flooding event is considered to be irrelevant to the determination of flood elevations with return periods of less than 500 years.

For each mechanism, the frequency of occurrence of causative events as well as the probability distribution of flood elevations at a given location due to the ensemble of events were determined according to the methodology given in "Methodology for Coastal Flooding in Southern California" (Reference 8). A brief outline of it is presented below:

Winter Swell

The statistics of flooding as the result of winter swell runup were determined using input data provided by the U.S. Navy Fleet Numerical Weather Center (FNWC). These input data consist of daily values of swell heights, periods, and directions at three deepwater locations beyond the continental shelf, bordering the study area.

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Table 1. Summary of Discharges

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-Year	50-Year	100-Year	500-Year
Soledad Canyon					
At Mouth	95.5	5,000	15,400	23,000	51,000
San Dieguito River[1]					
Upstream of Camino Del Mar Bridge	--[2]	5,700	31,400	41,800	90,000
Upstream of Atchison, Topeka & Santa Fe Railroad Bridge	--[2]	5,700	31,400	41,800	90,000
Upstream of Jimmy Durante Bridge	--[2]	5,800	32,100	42,400	90,000
Upstream of U.S. Interstate Highway 5 Bridge	--[2]	5,900	32,500	42,800	90,000

[1]Source from Leedshill-Herkenhoff, Inc.
[2]Data Not Provided by the Source

The data span from 1951 to 1974 and were computed by FNWC using input from ship observations, meteorological stations, and synoptic surface meteorological charts of the Pacific Ocean. For this study, the incoming swells provided by FNWC were classified into 12 direction sectors of 10 degrees band width each. (Exposure of the study area to winter swells was confined to a 120-degree band, i.e., swell coming from directions 220 degrees to 340 degrees T). Within each sector, 10 days of swell height and period values were selected from the 24 years of FNWC data to represent extreme flood-producing days. The selection criteria were guided by Hunts formula for runup. The 120 days at each of the three deepwater stations were merged to obtain a master list of 161 extreme runup producing days. For each of the 161 days, the input swell provided by FNWC was refracted across the continental shelf and converted to runup at selected locations in the study area. The techniques used and data required for this are described in Section 3.2. Of the 161 days, a number of groups of consecutive days could be identified.

Each such group of days is considered to represent one event only; the largest runup from each group of days was selected as the maximum runup for that event. As a result of refraction and island sheltering effects, a number of the input swells produced no significant runup at certain locations. Therefore, the number of extreme runup events is less than 161. The average number of events in the study area is approximately 40. For each location in the study area, the runup for the extreme events were fitted to a Weibull distribution to obtain a probability distribution of runup from winter swell. The Weibull distribution was found to be best suited for representing runup statistics (Reference 8). Because extreme winter swell runup lasts for at least one day, the maximum runup must be considered to coexist with the maximum high tide.

Regarding the extreme runup values as a statistical sample only, the influence of the astronomical tides was included by convolving the probability distribution of runup with the probability distribution of daily high tides. The latter was obtained from standard tide prediction procedures (Reference 9) using the harmonic constants at the nearest available tide gage for which such data exists (supplied by the National Oceanic and Atmospheric Administration, Tidal Prediction Branch). At each location, the frequency of occurrence of extreme events is determined by the number of runup values used in the Weibull curve fit. The number of years over which these occur is 24. The product of the frequency of occurrence with the complement of cumulative probability distribution of the runup plus tide (convolved) distribution gives the exceedence frequency curve for flood elevation due to winter swell runup.

Tsunamis

Elevation-frequency curves for tsunami flooding were obtained from information supplied by the U.S. Army Corps of Engineers, Waterways

Experiment Station (WES) (Reference 10). The use of the results of the WES study was directed by FEMA.

The statistics of tsunami elevations along the coastline were derived in the WES study by synthesizing data on tsunami source intensities, source dimensions, and frequencies of occurrence along the Aleutian-Alaskan and Peru-Chili Trenches. As a result, 75 different tsunamis, each with a known frequency of occurrence, were generated and propagated across the Pacific using a numerical hydrodynamic model of tsunamis. At a number of locations in the study area, these 75 tsunami time signatures were each added to the tidal time signature at the nearest tide gage location for which harmonic constants for tide computations are available. One year of tidal signature was generated from the harmonic constants. A given tsunami signature was then combined with the tide signature and the maximum of tsunami plus tide for the combination recorded. To simulate the occurrence of the tsunami at random phases of the tide, the tsunami signature was repeatedly combined to the tide signature starting at random phases over the entire year of tide signature. Each combination produces a maximum tsunami plus tide elevation, with frequency of occurrence equal to the frequency of occurrence of the particular tsunami signature used, divided by the total number of such combinations for that particular tsunami. The process was repeated for all 75 tsunamis, and the elevation frequency curve for tsunami flooding thus established.

Wind Waves from Landfalling Storms

The source of data for wind waves is the same as that for winter swell, namely, the FNWC (1951-1974) data. The stations for which daily height, period, and direction data are available are also the same as for winter swells. For obtaining runup statistics, the FNWC daily wave data were converted to daily runup data using the method outlined in Section 3.2 (Reference 8). The daily runup data was then fitted to a Weibull distribution and convolved with the tide in the same manner as for winter swells.

Tropical Cyclone Swell

Runup from swell generated by tropical cyclones off Baja California was computed using the techniques discussed in Section 3.2 (Reference 8). To establish the statistics of hurricane swell runup, the following procedure was used. Data concerning tropical cyclone tracks were obtained from the National Climatic Center (NCC).

The data comprise 12-hour positions of eastern North Pacific tropical cyclones from 1949 to 1974. These were supplemented by data on tropical cyclone tracks from 1975 to 1978 reported in various issues of the Monthly Weather Review (1976-1979).

Besides position data, storm intensities at each 12-hour position are also given. The intensity classifications are based on estimated maximum windspeeds. The intensity categories are tropical depression (less than 35 knot winds), tropical storm (less than 65 knot winds), and hurricane (at least 65 knot winds). Storms with tropical depression status were considered to generate negligible swell and were omitted from this study.

Data on actual maximum windspeeds were available from the NCC only from 1973 to 1977. These were used as the basis for obtaining values to represent maximum windspeeds from each of the two intensity classifications associated with the track data. Data on storm radii were derived from North American Surface Weather Charts by analysis of pressure fields of tropical cyclones off Baja California. These were used to define typical radius of maximum winds for each of two relevant intensity classes. For each tropical cyclone between 1949 and 1978, the hurricane wind waves were computed by using the mean radius and maximum windspeeds established for each intensity class along the track data. The swell and resultant runup were computed using the techniques described in Section 3.2 (Reference 8). For each tropical cyclone and each location of interest in the study area, a time history of swell runup was determined. These were added to time histories of the local astronomical tide in a procedure analogous to that used in determining tsunami-plus tide effects. The exceedence frequencies of tropical cyclone swell runup were computed in a manner similar to that used for tsunamis.

Landfalling Tropical Cyclones

The frequency of landfalling tropical cyclones in southern California is extremely low. During the years (1949 to 1974) covered by the NCC tape of eastern North Pacific tropical cyclones, no tropical cyclone hit southern California. A longer period of record was used to estimate the frequency of an event such as the Long Beach 1939 storm. A study of Pyke (Reference 11) was used to compile a list of landfalling tropical cyclones along the coast of southern California. The study was a result of extensive investigations of historical records such as precipitation and other weather and meteorogical data. The study spanned the period from 1889 to 1977 and showed only five or six identifiable landfalling tropical cyclones, of which the 1939 Long Beach event was the strongest and only one in the tropical storm category. The others were all weak tropical depressions (with maximum winds of less than 35 knots). This low-frequency event (once in 105 years over approximately 360 miles of coastline, coupled with an impact diameter of approximately 60 miles) implies that for any given location, the return period of a landfalling tropical cyclone is approximately 600 years. Therefore, landfalling tropical cyclones were not considered in this study.

At each location within the study area, the exceedence frequencies at a given elevation due to the various flood-producing mechanisms were assumed to give the total exceedence frequency at the flood elevation.

Elevations for floods of the selected recurrence intervals on the Pacific Ocean are shown in Table 2.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals.

To obtain runup values for the various flood-producing mechanisms, data on offshore bathymetry and beach profiles were obtained from U.S. Coast and Geodetic Survey and the National Oceanic and Atmospheric Administration bathymetric charts, U.S. Geological Survey topographic maps, surveys of beach profiles, and from aerial photographs of the study area (References 12, 13, 10, and 14, respectively).

Cross section data for Soledad Canyon were obtained from field surveys (Reference 15).

Cross section data for the San Dieguito River were obtained from digitized aerial surveys, field surveys, and local improvement plans (References 16 and 17).

All bridges were investigated to obtain elevation data and structural geometry.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the Flood Boundary and Floodway Map (Exhibit 2).

Hydraulic roughness coefficients (Manning's "n") used in the hydraulic computations were chosen by engineering judgment and were based on field observations of the channels and flood plain areas. These values were 0.035 for the channel and 0.040 for overbank areas of Soledad Canyon. Value for the San Dieguito River ranged from 0.030 to 0.035 for the channel and from 0.030 to 0.045 for the overbank areas.

Starting water-surface elevations for Soledad Canyon were derived from normal-depth calculations. Starting water-surface elevations for the San Dieguito River were based on the Mean Higher High Water Level for the Pacific Ocean.

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Table 2. Summary of Elevations

Flooding Source and Location	Elevation (Feet) 10-Year	50-Year[1]	100-Year	500-Year
Pacific Ocean				
From Northern Corporate Limits to Near Mouth of the San Dieguito River	8.50		11.80	14.10
At Right Overbank of the Mouth of the San Dieguito River	7.40		9.95	12.05
From Mouth of the San Dieguito River to 500 Feet South of 18th Street	6.30		8.10	10.00
From 500 Feet South of 18th Street to the Intersection of Ocean Avenue and 15th Street	6.85		8.90	10.99
At the Intersection of Ocean Avenue and 15th Street to 10th Street	7.30		9.60	11.78
From Just North of 7th Street to 500 Feet South of 4th Street	8.45		11.64	13.90
From 500 Feet South of 4th Street to Southern Corporate Limits	8.00		10.62	12.80

[1]Data Not Available

Elevations for areas or riverine flooding studied by detailed methods were computed using the U.S. Army Corps of Engineers HEC-2 computer program (Reference 18). Flood profiles were drawn showing computed water-surface elevations to an accuracy of 0.5 feet for floods of the selected recurrence intervals (Exhibit 1).

Because of the limited amount of flooding affecting Del Mar from Soledad Canyon, no flood profiles are presented. Flood profiles of the San Dieguito River are presented because of the areal extent and severity of flooding from this source.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

Scouring of the riverbed at the mouth of the San Dieguito River was assumed to -4 feet. To simulate the 1980 flood, a discharge of 22,000 cfs was applied. The flooding results at the lower end of San Dieguito River are in close agreement with the flood map provided by the City of Del Mar.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in this study are shown on the maps.

Refraction

Refraction computations were conducted to trace the evolution of winter swell and tropical cyclone swell from their source to the 60-foot depth contour. A large grid (200 by 250 miles) covering the coastal water of southern California with 1,000 by 1,000-foot grid spacing was used for the refraction calculations. Standard raytracing procedures were used to trace rays inward from the deep ocean grid boundaries. Ray spacing was chosen at 1,000 feet to provide adequate density of ray coverage. Wave heights at the 60-foot contour were computed using the principle of wave energy flux conservation between neighborhood rays. One set of refraction computations was performed for each selected event from the list of extreme winter swells and the list of tropical cyclones off Baja California. The winter swell input values were obtained from the FNWC tape for the selected days of extreme events. The values at the three FNWC stations were the basis for linear interpolation to obtain input values between them. For swell generated by tropical cyclones, the procedure outlined below (tropical cyclone swell) was used to provide input to the refraction program.

Wave Runup

Shoreward of the 60-foot contour, wave runup was determined for each beach profile of interest by adapting to composite beaches

the standard empirical runup formulas valid for uniformly sloping beaches. The results of the refraction calculations were used as input. The beach profiles selected were assumed to be locally one-dimensional to apply the empirical runup formulas. However, the influence of incident wave directions, refraction, and shaling effects was taken into consideration. Wave heights within the surf zone were also computed using empirical formulas to establish the zone where waves exceed 3 feet. This is needed for V Zone designation. Additional details of the procedures used are available in Reference 7.

Tsunamis

Tsunamis were computed using numerical models of the long wave equations describing tsunami behavior. The results were taken from the U.S. Army Corps of Engineers study which details the method used to compute tsunami behavior (Reference 10).

Tropical Cyclone Swells

Waves generated by a tropical cyclone were determined using the JONSWAP spectrum with empirically derived shape and intensity parameters, which were correlated to radial position and windspeed (Reference 18). A cosine function based on the local wind direction was used for the directional distribution function of the spectrum. The size of the tropical cyclone was defined by the radius at which the windspeed drops below 35 knots. The details of the model are given in Reference 8.

Dames & Moore was contracted by FEMA to do a regression analysis of coastal flooding along the shoreline of Del Mar.

The data obtained from this analysis were used to revise the coastal analysis in Del Mar from approximate to detailed and to update the analysis done by Tetra Tech, Inc.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study produces maps designed to assist communities in developing flood plain management measures.

4.1 Flood Boundaries

To provide a national standard without regional discrimination, the 1 percent annual chance (100-year) flood has been adopted by FEMA as the base flood for flood plain management purposes. The 0.2 percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For each stream

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studied in detail, the 100- and 500-year flood plain boundaries have been delineated using the flood elevations determined at each cross section. For the San Dieguito River and Soledad Canyon Creek, flood boundaries were delineated using topographic maps at a scale of 1:2,400, with a contour interval of 5 feet (Reference 20). For coastal areas studied by Tetra Tech, flood boundaries were delineated using topographic maps at a scale of 1:4,800, with a contour interval of 2 feet (Reference 21).

For the Dames & Moore regression analysis, flood boundaries were delineated using topographic maps at a scale of 1:24,000 (enlarged to a scale of 1:6,000) with a contour interval of 20 feet (Reference 22) along with the maps used by Tetra Tech (Reference 20).

The 100- and 500-year flood plain boundaries are shown on the Flood Boundary and Floodway Map (Exhibit 2). In cases where the 100- and 500-year flood plain boundaries are close together, only the 100-year flood plain boundary has been shown. Small areas within the flood plain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

4.2 Floodways

Encroachment on flood plains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood plain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent flood plain areas, that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this study were computed on the basis of equal conveyance reduction from each side of the flood plain. The results of these computations are tabulated at selected cross sections for each stream segment for which a floodway is computed (Table 3).

As shown on the Flood Boundary and Floodway Map (Exhibit 2), the floodway boundaries were computed at cross sections. Between cross sections, the boundaries were interpolated. In cases where the

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
San Dieguito River								
A	642	920	6,206	7.1	10.7	10.7	10.7	0.0
B	1,918	541	5,247	9.1	15.0	15.0	15.0	0.0
C	2,428	469	5,168	9.7	15.6	15.6	15.6	0.0
D	3,156	772	10,328	4.5	18.1	18.1	18.7	0.6
E	5,333	1,082	13,465	3.7	18.5	18.5	19.2	0.7

[1]Feet Above Mouth

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF DEL MAR, CA
(SAN DEIGO CO.)

FLOODWAY DATA

SAN DIEGUITO RIVER

floodway and 100-year flood plain boundaries are either close together or collinear, only the floodway boundary has been shown.

The area between the floodway and 100-year flood plain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood by more than 1 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 2.

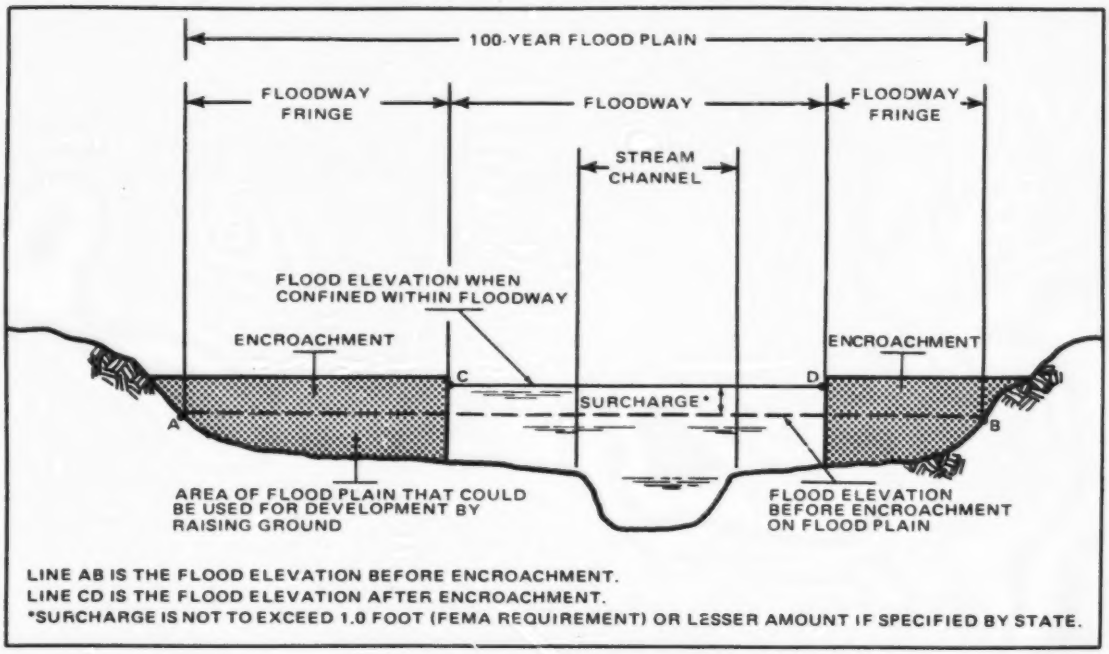
100-YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE*
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE AB IS THE FLOOD ELEVATION BEFORE ENCROACHMENT.
LINE CD IS THE FLOOD ELEVATION AFTER ENCROACHMENT.
*SURCHARGE IS NOT TO EXCEED 1.0 FOOT (FEMA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE.

Figure 2. Floodway Schematic

5.0 INSURANCE APPLICATION

To establish actuarial insurance rates, data from the engineering study must be transformed into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors, and flood insurance zone designations for each flooding source studied in detail affecting the City of Del Mar.

5.1 Reach Determinations

Reaches are defined as sections of flood plain that have relatively the same flood hazard, based on the average weighted difference in

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water-surface elevations between the 10- and 100-year floods. This difference may not have a variation greater than that indicated in the following table for more than 20 percent of the reach:

Average Difference Between 10- and 100-Year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The locations of the reaches determined for the flooding sources of the City of Del Mar are shown on the Flood Profiles (Exhibit 1) and summarized in Table 4.

Reaches are defined as sections of flood plain that have relatively the same flood hazard. In tidal areas, reaches are limited to the distance for which the 100-year flood elevation does not vary more than 1.0 foot. Using these criteria, 8 reaches were required for the flooding source of the Pacific Ocean. The locations of these reaches are shown on the Flood Insurance Rate Map.

5.2 Flood Hazard Factors

The Flood Hazard Factor (FHF) is used to establish relationships between depth and frequency of flooding in any reach. This relationship is then used with depth-damage relationships for various classes of structures to establish actuarial insurance rate tables.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations rounded to the nearest one-half foot, multiplied by 10, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year flood water-surface elevations is greater than 10.0 feet, it is rounded to the nearest whole foot.

5.3 Flood Insurance Zones

Flood insurance zones and zone numbers are assigned based on the type of flood hazard and the FHF, respectively. A unique zone number is associated with each possible FHF, and varies from 1 for a FHF of 005 to a maximum of 30 for a FHF of 200 or greater.

Zones A4, A5, A6, A10, and A16: Special Flood Hazard Areas inundated by the 100-year flood; with base flood elevations shown, and zones subdivided according to FHFs.

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FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Pacific Ocean							
Reach 1	0001	-3.30	N/A	2.30	035	V7	12
Reach 2	0001	-2.55	N/A	2.10	025	V5	10
Reach 3	0001	-1.80	N/A	1.90	020	V4,A4	8
Reach 4	0001	-2.05	N/A	2.09	020	V4,A4	9
Reach 5	0001	-2.30	N/A	2.18	025	V5,A5	10
Reach 6	0001	-2.75	N/A	2.22	030	V6,A6	11
Reach 7	0001	-3.14	N/A	2.26	030	V6,A6	12
Reach 8	0001	-2.62	N/A	2.18	025	V5,A5	11
Soledad Canyon							
Reach 1	0001	-4.89	-1.90	5.77	050	A10	11
San Dieguito River							
Reach 1	0001	-7.8	-1.8	6.3	080	A16	Varies - See Map

[1]Flood Insurance Rate Map Panel [2]Weighted Average [3]Rounded to Nearest Foot

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF DEL MAR, CA
(SAN DEIGO CO.)

FLOOD INSURANCE ZONE DATA

PACIFIC OCEAN-SOLEDAD CANYON-SAN DIEGUITO RIVER

Zones V4, V5, V6, and V7:	Special Flood Hazard Areas along coasts inundated by the 100-year flood that have additional velocity hazards associated with waves of 3-foot amplitude or greater; with base flood elevations shown, and zones subdivided according to FHFs.
Zone B:	Areas between the Special Flood Hazard Areas and the limits of the 500-year flood; areas that are protected from the 100- or 500-year floods by dike, levee, or other local water-control structure; areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.
Zone C:	Areas of minimal flood hazard; not subdivided.

The flood elevation differences, FHFs, flood insurance zones, and base flood elevations for each flooding source studied in detail in the community are summarized in Table 4.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the City of Del Mar, California, is, for insurance purposes, the principal product of the Flood Insurance Study. This map contains the official delineation of flood insurance zones and base flood elevations. Base flood elevation lines show the locations of the expected whole-foot water-surface elevation of the base (100-year) flood. The base flood elevations and zone numbers are used by insurance agents, in conjunction with structure elevations and characteristics, to assign actuarial insurance rates to structures and contents insured under the NFIP.

6.0 OTHER STUDIES

Flood Insurance Studies for the City of San Diego (Reference 23) and the unincorporated areas of San Diego County (Reference 24) are in agreement with this Flood Insurance Study.

The previous Flood Insurance Studies only cover the flooding at the coastal zone of the City of Del Mar. No riverine flooding was included. This study includes the San Dieguito River within the City of Del Mar.

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This supersedes the 1975 Flood Hazard Boundary Map for Del Mar (Reference 25) and the 1983 Flood Insurance Study for the City of Del Mar (Reference 15).

The County of San Diego has flood plain and floodway maps for San Dieguito River. Their analyses were based on a fluvial (movable bed) model with significant scouring at bridge. The flowrate used by the county is 46,000 cfs at the river mouth and 50,000 cfs upstream. These flowrates were higher than those used in this Flood Insurance Study. The fluvial model does not show the same cross sections as the fixed-bed model; therefore, the water-surface elevations are different, especially at the bridge crossings.

This Flood Insurance Study is authoritative for purposes of the NFIP and the results presented supersede the previous flood determinations.

7.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting the Natural and Technological Hazards Division, FEMA, Building 105, Presidio of San Francisco, San Francisco, California 94129.

8.0 BIBLIOGRAPHY AND REFERENCES

1. California Coastal Commission, Wave Damage Along the California Coast, Winter, 1977-78, Steve Howe, December 1978

2. U.S. Department of Agriculture, Weather Bureau, Monthly Weather Review, September 1939

3. San Diego Union, various dates

4. G.G. Kuhn and F.P. Shephard, "Accelerated Beach-Cliff Erosion Related to Unusual Storms in Southern California," California Geology, March 1979

5. U.S. Department of the Army, Corps of Engineers, San Francisco District and Los Angeles District, Winter Storm Damage Along the California Coast 1977-78, prepared by George W. Domurat, 1978

6. Leedshill-Herkenhoff, Inc., San Dieguito River Flood Studies, May 1985

7. U.S. Department of the Army, Corps of Engineers, Generalized Standard Project Rainflood Criteria for Southern California Coastal Streams, 1967

8. Tetra Tech, Inc., "Methodology for Coastal Flooding in Southern California," by Y.K. Lee et al., December 1979

9. U.S. Department of Commerce, Coast and Geodetic Survey, Special Publication 98, Manual of Harmonic Analysis and Prediction of Tides, P. Shureman, 1941

10. U.S. Department of the Army, Corps of Engineers, Waterways Experiment Station, Type 19 Flood Insurance Study: Tsunami Predictions for Southern California, prepared for the Federal Insurance Administration by J.R. Houston, September 1980

11. C.B. Pyke, Some Meteorological Aspects of the Seasonal Distribution of Precipitation in the Western United States and Baja California, University of California WRC Contribution 139, October 1972

12. U.S. Department of Commerce, Coast and Geodetic Survey and the National Oceanic and Atmospheric Administration, Bathymetric Charts, California Coastline, various dates

13. U.S. Department of the Interior, Geological Survey, 7.5-Minute Series Topographic Maps, Scale 1:24,000, Contour Interval 20 feet: National City, California (1967), Photorevised (1975); Imperial Beach, California - Baja, California Norte (1967), Photorevised (1975)

14. Abrams Aerial Survey, Inc., Aerial Photographs, California Coastline, Scale 1:4,800, August 1978

15. Federal Emergency Management Agency, Flood Insurance Study, City of Del Mar, California, April 1983

16. Harl Pugh and Associates, Aerial Photographs, Scale 1:12,000, October 1983

17. San Diego County, Plans for Construction of Jimmy Durante Boulevard, January 1984

18. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, HEC-2 Water Surface Profiles, Davis, California, 1977

19. Y.K. Lee, "Hurricane Eloise Wave Spectra," in Coastal Engineering, 4, pp. 151-156, 1980

20. San Diego County, Topographic Maps, Scale 1:2,400, Contour Interval 5 feet, aerial photography flown July 26, 1973, and April 21, 1977

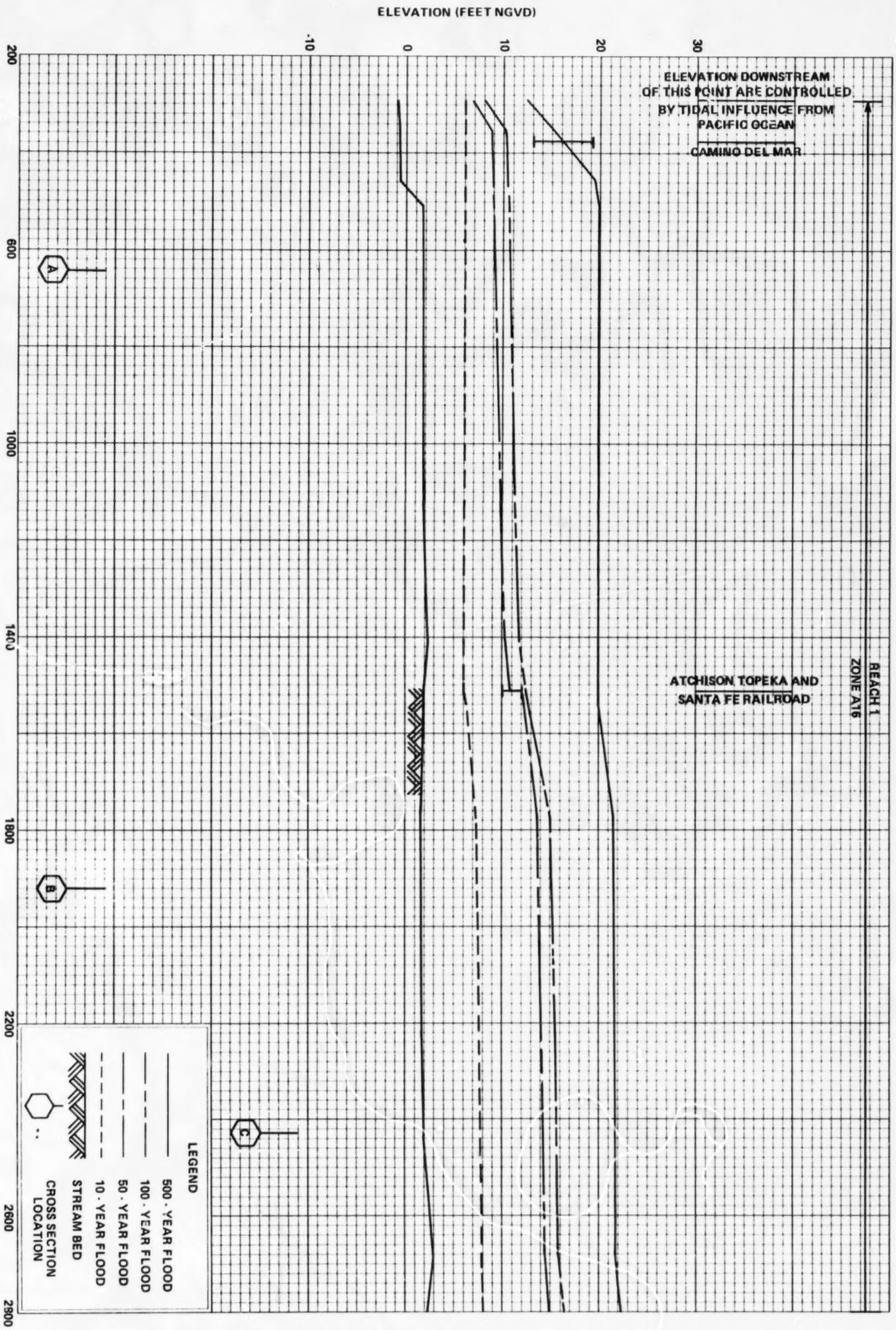
21. Abrams Aerial Surveys, Inc., Topographic Maps, Scale 1:4,800, Contour Interval 2 feet, October 1978

22. U.S. Department of the Interior, Geological Survey, 7.5-Minute Series Topographic Maps, Scale 1:24,000, Contour Interval 20 feet: Del Mar, California (1967), Photorevised (1975)

23. Federal Emergency Management Agency, Flood Insurance Study, City of San Diego, California, unpublished

24. Federal Emergency Management Agency, Flood Insurance Study, San Diego County, California (Unincorporated Areas), 1983

25. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Hazard Boundary Map, City of Del Mar, California, Scale 1:6,000 revised October 17, 1975



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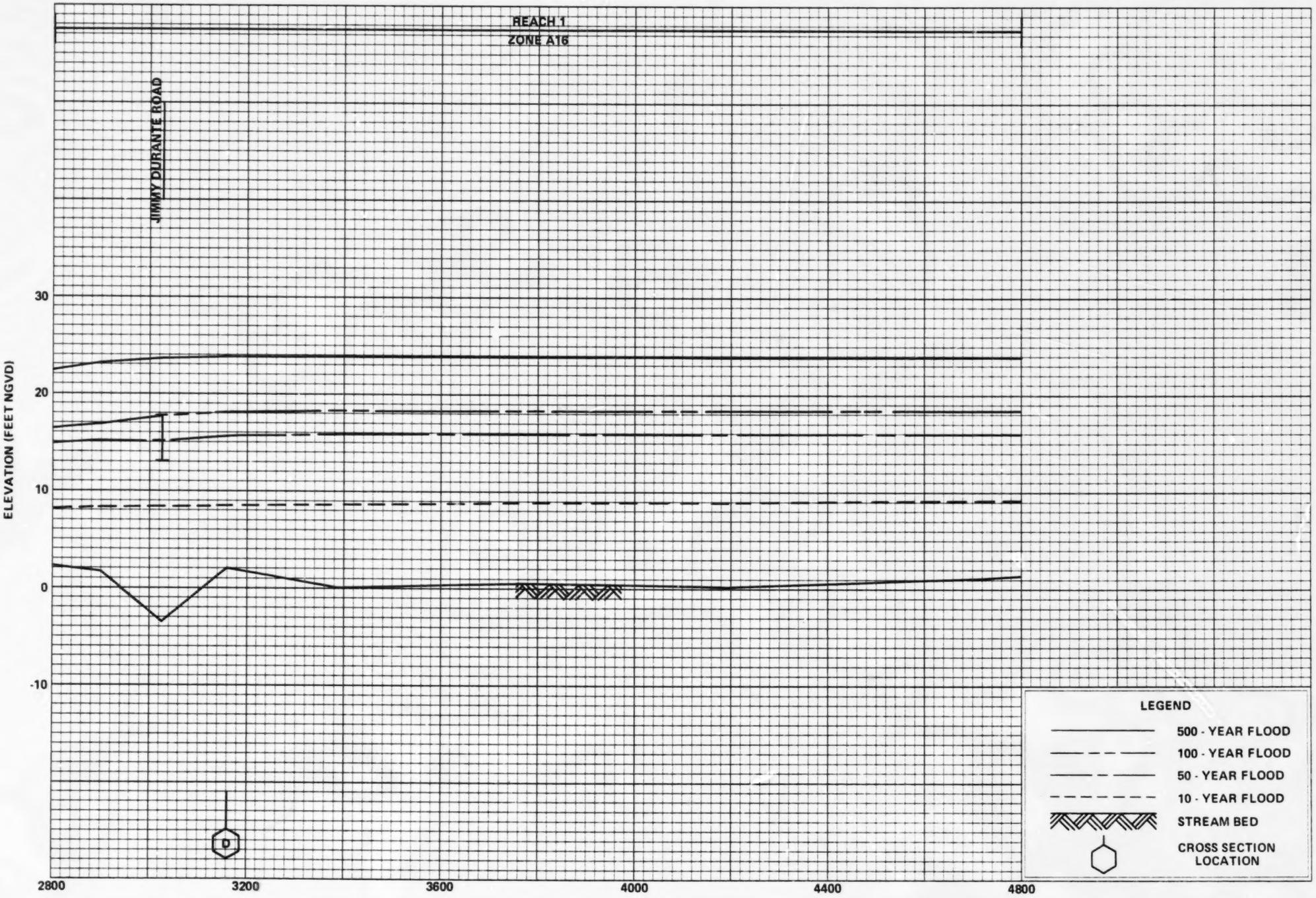

FLOOD PROFILES

SAN DIEGUITO RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF DEL MAR, CA
(SAN DEIGO CO.)

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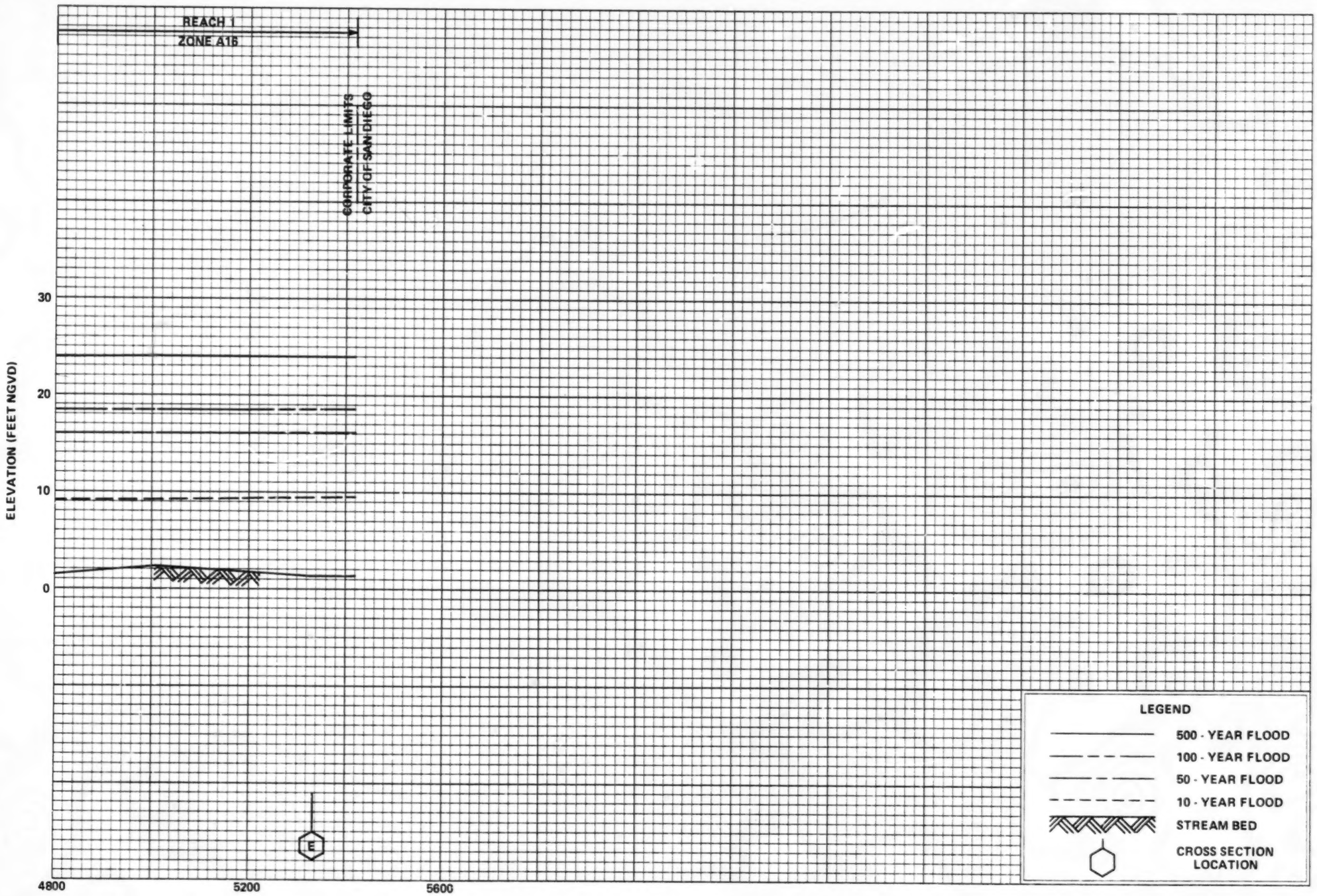

FLOOD PROFILES

SAN DIEGUITO RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF DEL MAR, CA
(SAN DIEGO CO.)

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